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Evaluation of the SPICE auditory training curriculum

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Independent Study Project

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INTRODUCTION

The cochlear implant is a device designed to provide sound to individuals with severe and profound sensorineural hearing losses who show no significant benefit from conventional amplification. It is proving to be a successful device for many children to hear and perceive speech. The use of the cochlear implant is fundamental in not only hearing speech, but for learning speech and language, as well.

The principal use of the cochlear implant is to aid in the skill of speech perception which will hopefully improve communication skills. This skill is not one that is automatically acquired when the device is first utilized. Much training is involved in the process of learning to use and understand speech signals. The Speech Perception Instructional Curriculum and Evaluation (SPICE) (Moog, Biedenstein, and Davidson, 1995) auditory training protocol was developed at the Central Institute for the Deaf for the very purpose of developing and maintaining the skill of auditory speech perception. The purpose of this study was to evaluate children's progress on the SPICE auditory training protocol and relate this progress to their performance on a speech perception test battery.

Speech Perception Test Battery

A speech perception test battery has been assembled to measure the auditory skills of profoundly hearing impaired children. Scores on this battery were used to place the children into one of 6 speech perception categories. These categories may be used by both teachers and audiologists to describe the children's speech perception abilities.

The speech perception categories are as follows. Category 0 is used when the child does not demonstrate any ability to detect speech at a normal conversational level (65 dBHL) or more. If a child is able to detect a speech signal, he is placed in Category 1. When a child can differentiate words with different temporal or speech patterns, he is then considered a Category 2. The child that is able to differentiate among a closed set of words on the basis of phoneme information rather than overall pattern alone demonstrates beginning word identification and called a Category 3. Category 4 is used to describe a child who is able to differentiate among a closed set of words which differ primarily in their vowel sounds. Word identification through consonant recognition describes a child who can differentiate among a closed set of words which have the same vowel sound, but have different consonants. This child is a Category 5. The final category is a Category 6, which means that the child is able perform open-set word recognition and is able to listen to words presented out of context and extract enough phoneme information to recognize the word through audition alone.

The following test battery was administered to assign category labels, The CID Early Speech Perception (ESP) Test (Moog and Geers, 1994).There are two forms of the ESP, a 12-choice standard version which is administered to most children over 5 years of age and a 4-choice low-verbal version, which is administered to younger children with limited language and vocabulary. If the child is unable to perform the tasks as part of the standard version of the ESP, he is administered the low-verbal version, which uses smaller sets and objects rather than picture cards. Because the guessing rate is higher on this version than on the standard version of spondee and monosyllable identification, a higher percent correct score is needed to be significantly above chance level. The ESP tests

pattern perception, spondee identification, and monosyllable identification and is therefore used to assign category labels 2, 3 and 4.

The pattern perception subtest consists of words differing in duration and stress patterns. A score of at least 66% correct is required in order for the child to be considered able to consistently perceive temporal patterns (Category 2) and continue on to the next subtest. A score below 66% would classify the child as a Category 1 if he is able to obtain a speech awareness threshold, a Category 0 is he does not detect speech. The next ESP subtest to be administered is Spondee Identification, which consists of words having two equally stressed syllables. In order to continue onto the next subtest, the child must score at least 33% on the spondees, which would then place him in Category 3. The monosyllable identification subtest is administered to those who score at least 75% on the spondaic words. The words used in this subtest all begin with the letter "b" and most end with a stop consonant, but contain different vowel sounds. The child is placed in Category 4 if he scores at least 50% on this subtest, 80% on the low-verbal version.

The Word Intelligibility by Picture Identification Test (WIPI) (Ross and Lerman, 1971) was administered to two of the subjects in this study, as those who reach Category 4 proceed with testing to determine if they may be considered a Category 5. A score of 28% or higher on the WIPI indicates consonant recognition ability which places the child into Category 5.

The Kindergarten Phonetically Balanced Word List (PBK) (Haskins, 1949), is an open-set task. If the child correctly identifies three of the words on the 25 item

list, he is then considered to be a Category 6, and may possibly be expected to understand some conversational speech through audition alone.

Auditory Training Protocol

The SPICE auditory training curriculum is used by instructors to develop speech perception abilities of deaf children by using audition alone. The curriculum provides a guideline and lessons for instructors to follow when implementing auditory training with the children. The lessons should last for about 15 minutes per day due to the high level of concentration on the part of the student. "The sequence of the lessons is designed to practice a continuum of skills from discrete tasks, such as discriminating and identifying words to more global skills focusing on connected speech." (Moog, Biedenstein, and Davidson, 1995).

The first section of the SPICE is called Detection. Detection must be achieved in order for the child to proceed to the higher level speech perception skills. The tasks in this area are designed to elicit a response to speech. The child is not required to correctly identify the speech sounds, he only needs to respond to whether or not he heard them.

The next two sections are designed to be practiced in parallel with each other, as the tasks become increasingly difficult. The suprasegmental section consists of skills that require the child to differentiate speech sounds according to durational and/or stress patterns. As the instructor proceeds down the column the sets not only become larger, but increase in difficulty as the stimuli become more alike in pattern. The Vowel and Consonant Perception Section requires the child to "differentiate among stimuli that have the same duration, stress and intonation,

and differ only in vowels and consonants." (Moog, et al.) Once the child has successfully progressed through half this section, it is then time to begin working on Connected Speech.

The Connected Speech section works on the skill of perception in the context of phrases and sentences rather than single words. The ultimate goal for the child is to be able to perceive words and connected speech which is a reflection of communication in every day life. The skills acquired in this section further assist the child to transfer learned skills into natural situations.

There is a rating form in which the instructor can document the child's progress and follow along, selecting new objectives to work on when attempting to acquire each skill. (Appendix A) A slash mark is used when the child is working on a task, but has not fully acquired the skill. When a skill is acquired an "X" is marked next to the objective on the form. The date when the task is acquired is also marked on the form. To acquire a skill, the child must demonstrate the ability to correctly identify the target stimuli in at least five sets with 90% accuracy. If the child is not able to do so, the skill is considered to be emerging and a slash mark is used.

METHOD

SUBJECTS

Four subjects were evaluated in this study, all of whom were students at the Central Institute for the Deaf in St. Louis, Missouri. The criterion for inclusion in this study was that the subject had recently received a Nucleus 22 Cochlear Implant .

Each subject was trained with the same instructor. Weekly lesson plans were made containing the objectives to be targeted in those sessions. Each subject met with the instructor 2-3 times per week for approximately 15-20 minutes per session. Speech perception test scores and category placements were obtained prior to and after the training period in order to measure the success of the auditory training sessions using the SPICE protocol.

The pre-tests were administered utilizing the devices worn prior to implantation. The pre-training characteristics of the 4 children are summarized in Appendix B.

The first subject, Child A was twelve years old at the time of the study. The cause of deafness is thought to be meningitis at 9 months of age. The subject's hearing loss progressed over time from a moderately severe loss to a profound loss and was implanted at the age of twelve. Initial stimulation occurred on March 20, 1995. Pre-training scores were obtained in the binaural aided condition. Auditory training sessions were conducted twice weekly. for twenty minutes.

Child B was also 12 years old at the time of the study. The cause of deafness is unknown and was diagnosed at 1 year, 11 months. The initial stimulation of this subject's device was performed on March 17, 1995. Pre-training scores were obtained in the binaural aided condition. Auditory training began on the day of the initial stimulation and sessions were held three times weekly for twenty minutes each.

Child C was five years old at the time of the study and was deafened by meningitis at 11 months of age. This subject had previously worn a Nucleus 22

Cochlear Implant, but because of difficulties encountered due to partial insertion of the electrode array, the subject underwent a second surgery and was re-implanted in January of 1995. Pre-training scores were obtained with a hearing aid worn on the right ear. Auditory training began with this subject two months after initial stimulation. This subject had training sessions 2-3 times weekly for approximately 15 minutes. Short sessions were used due to the young age and limited attention span of the subject.

Child D was 11 years old at the time of the study. The cause of deafness is unknown and was diagnosed at 9 months of age. This subject had previously worn a House 3-M Single Channel Cochlear Implant since the age of 5, but due to limited benefit the subject was re-implanted with the Nucleus 22 in September of 1994. Initial stimulation of the device was performed in October of 1994. Pre-training test scores were obtained with the Nucleus 22. Auditory training began with this subjects five months after stimulation of the new device, 3 times per week, for 20 minutes.

PROCEDURE

Auditory Training

Lesson plans were developed weekly for each subject, selecting a few objectives at a time to be acquired. Materials included in the SPICE kit were utilized in training. For the older subjects, picture cards and handwritten words were used as stimuli for the training sessions. The younger subject required more tangible stimuli and therefore, small objects as well as picture cards were used.

The instructor's face was covered with a black screen covered hoop, so the subject could not see any expression or movement of the instructor's face. The subject sat across the table from the instructor in a small, acoustically treated room. The subject was instructed to point to the appropriate stimulus when prompted by the instructor. When the subject was able to correctly identify the stimuli 90% of the time with five different sets, it was then considered that the subject had acquired that particular skill. If the subject was not able to perform the task, the instructor would move on to another task and return to the emerging tasks in subsequent sessions until the skill was ultimately acquired.

Speech Perception Testing

The subjects were evaluated both before and after the training period with the ESP test battery. The scores can be found in the tables in Appendix B.

RESULTS

In order to analyze the results from the training sessions, points were assigned as follows: one point was given for each acquired skill. If the subject was emerging on a particular skill, a half of a point was assigned and upon acquisition of that skill, the other half point was then assigned. These points are plotted on a graph as a function of the number of training sessions (Appendix B).

Improvement was noted in most of the subjects' speech perception skills. The degree of improvement, however, was varied among the subjects. Scores on the Pattern Perception subtest of the ESP increased with an average of 9.5% across subjects post-training. A clinically significant increase in scores of 28.25% was

noted for the Spondee Identification subtest of the ESP across subjects. The Monosyllable Identification subtest yielded an average increase of 15% across subjects. Child A's scores were increased by 20% on both the WIPI and the PBK..

Prior to the SPICE training, Child A scored in speech perception Category 4 (vowel identification). After completion of the study, he scored in Category 6 (open-set). (Individual sub-test scores pre-and post-training can be found in Appendix B.) Although this subject did receive a cochlear implant long after onset of deafness, he made tremendous improvement over a short period of time. This may be perhaps due to the fact that his hearing loss was progressive and he had some auditory memory. His rate of progress on the SPICE checklist was likewise accelerated, exhibiting mastery of 3-4 skills per session, suggesting that he may not have been learning the sounds, rather he was re-familiarizing himself with them.

Child B remained a Category 3 following the training period, but scores on the individual subtests of pattern perception and spondee identification of the ESP did improve. This subject made steady progress on the SPICE checklist, acquiring 1-2 skills per session.

Child C improved from a Category 1 to a Category 5 after completion of the study. The rate of progress for this subject was 1-2 skills per session. This was possibly a result of the shorter session (10-15 minutes) due to limited attention span. Fewer tasks were targeted each training session due to the young age of the subject, which suggests that the subject may have been able to acquire skills faster if the instructor did not have to adjust to the subject's attention level.

Child D remained in the Category 3 post-training. This subject was also administered the ESP during the training period and those results are reported along with the other scores in Appendix B.

DISCUSSION

It was found that the ESP scores accurately reflect progress on the SPICE. Mastery of the suprasegmental portion of the SPICE corresponds with performance on the pattern perception subtest of the ESP. Mastery of the vowel perception section on the SPICE corresponds with the spondee and monosyllable subtests of the ESP, and mastery of consonant perception corresponds with WIPI scores. The scores obtained on these subtests not only give information as to the level of where the child is at in their auditory based knowledge and skill, but may be used to give the teacher the appropriate place to begin training.

With the exception of Child A, who was already a Category 4 when the study began, it was determined by reviewing the data that the ideal rate of progress is the acquisition of 1-2 skills per session. The training sessions for Child A appeared to constitute review sessions, as he acquired skills in a more rapid manner. For a child with this degree of skill, it would be more beneficial to start further down the hierarchy of skills on the SPICE checklist and to do so with large sets and concentration on consonant perception. It would also be beneficial to start on the tracking portion of the SPICE protocol and begin helping the child to develop skills to identify random auditory information, which corresponds to open-set speech perception.

This study found that children who were a Category 3 had already acquired the skills associated with suprasegmentals and should begin training on consonants and increased stimuli sets for vowels. For children in Category 4, they already possess the skill of discriminating between small sets and need to be concentrating on consonants and tracking abilities.

Those children in Category 2 or below, should start at the beginning of the SPICE checklist. If they are acquiring more than the ideal rate of progress, more than 1-2 skills per session, they should begin increasing the number of stimuli in each set.

The results of this study show the benefit of auditory training on improving listening skills. The SPICE auditory training curriculum is an effective means of achieving these goals. The ESP is also a valuable tool in not only measuring these abilities and demonstrating progress over time, but in choosing an appropriate place to begin training, as well.

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APPENDIX A

Suprasegmental Perception

A. Discriminate between 2 stimuli differing in duration, stress and / or intonation

____ Long continuous vs. short discrete:
Shhh vs. Boo

____ Continuous vs. intermittent:
Mooo vs. Tick-tock, tick-tock

____ Sentence vs. phrase or word:
The little girl kissed the baby. vs. Jump!

____ Words varying in number of syllables:
ball vs. ice cream cone
moon vs. french fries

____ Songs / Nursery Rhymes:
Jack and Jill vs. Happy Birthday to You
One, Two, Buckle My Shoe vs. Pop Goes The Weasel

B. Identify among 3 stimuli differing in duration, stress and / or intonation

____ Continuous vs. discrete vs. intermittent:
Shhh vs. Boo! vs. Honk, honk, honk!

____ A word vs. a phrase vs. a sentence:
sheep vs. knock, knock, knock vs.
The boy walked around the yellow chair.

____ Sentences: The cat jumped.
The boy and girl walked to the store.
Zoom, zoom goes the car.

____ Words varying in number of syllables:
cheese / hotdog / birthday cake

____ Songs / Rhymes:
Jingle Bells / I'm A Little Teapot /
Open, Shut Them

C. Identify among 4 stimuli differing in duration, stress and / or intonation

____ Phrases and sentences.

____ Words varying in number of syllables:
fish / hotdog / chicken / ice cream cone

____ Songs / Rhymes

D. Differentiate stimuli with similar duration but differing in stress and intonation

DISCRIMINATE BETWEEN 2 STIMULI

____ Sentences: The girl likes to eat cheese
The bubbles went pop, pop!

____ Words: chicken vs. hotdog
birthday cake vs. hamburger

IDENTIFY AMONG 3 STIMULI

____ Sentences: The boy pulled the blue boat.
Cheep, cheep, cheep says the chick.
Ssss! The snake crawled away.

E. Identify among sentences differing only in duration of key words

____ Sentences differing in one key word at end of sentence: Give me the *ball.*
Give me the *zebra.* Give me the *hamburger.*

____ Sentences differing in one key word in middle of sentence: Put the *ball* in the box.
Put the *french fries* in the box.
Put the *ice cream cone* in the box.

____ Sentences differing in two key words
Put the *hotdog* on the *plate.*
Put the *cup* on the *table.*
Put the *hamburger* in the *refrigerator.*

Vowel & Consonant Perception

A. Identify six sounds -o-, oo, ee, s, sh, m

____ Any two sounds

____ Any four sounds

____ All six sounds

B. Identify words differing in vowels and consonants

DISCRIMINATE BETWEEN 2 WORDS:
Monosyllables

____ Diphthong vs. Group 3
cake vs. fish

____ Diphthong vs. Group 1
boat vs. foot

____ Diphthong vs. Group 2
slide vs. cup

____ Group 1 vs. Group 3
ball vs. fish

____ Group 2 vs. Group 3
bird vs. chin

____ Group 1 vs. Group 2
boot vs. shirt

Multisyllabic Words

____ Three-syllable words
hamburger vs. Santa Claus

____ Spondees
toothbrush vs. mailman

____ Trochees
chicken vs. table

IDENTIFY AMONG 4 WORDS:

____ Monosyllables

____ Spondees

____ Three-syllable words

____ Trochees

IDENTIFY AMONG 8 WORDS:

____ Monosyllables

____ Spondees

____ Three-syllable words

____ Trochees

C. Vowel perception in words

DISCRIMINATE BETWEEN 2 WORDS:

____ Diphthong vs. Group 3
pie vs. pea

____ Diphthong vs. Group 1
boat vs. boot

____ Diphthong vs. Group 2
kite vs. cut

____ Group 1 vs. Group 3
moon vs. man

____ Group 2 vs. Group 3
hot vs. hit

____ Group 1 vs. Group 2
caught vs. cut

IDENTIFY AMONG 4 WORDS:

____ Any four

D. Consonant perception in words

____ Discriminate between 2 words
moon vs. school

____ Identify among 4 words
boat / coat / bone / phone

____ Identify among 6 words
cheese / leaf / sheep / feet / peas / knee

Connected Speech

(Begin this section once Client identifies words in sets of 6 to 8 based on Vowel and Consonant Perception.)

A. Identify key words in sentence context

____ One key word at end of sentence

____ One key word in middle of sentence

____ Two key words in a sentence

B. Identify practiced sentences

____ Responds appropriately

____ Repeats

C. Converse with picture context

____ Responds appropriately

____ Repeats

D. Converse about familiar topic

____ Answers questions

____ Converses

E. Connected Discourse Tracking

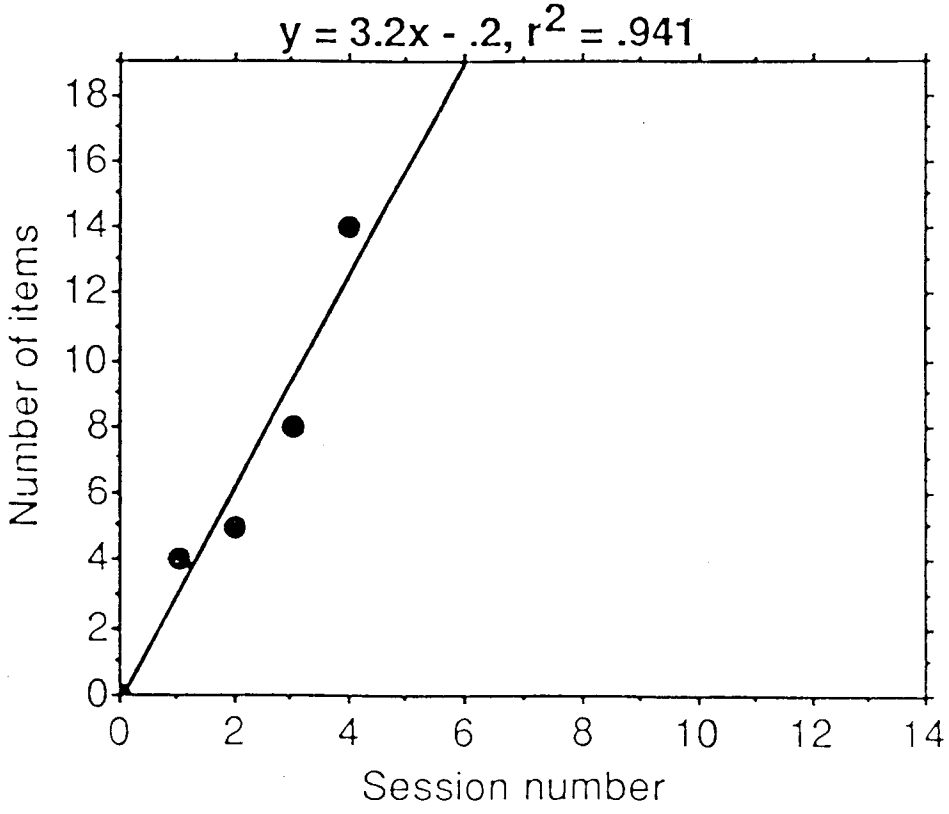
____ Repeats

____ Answers questions

APPENDIX B

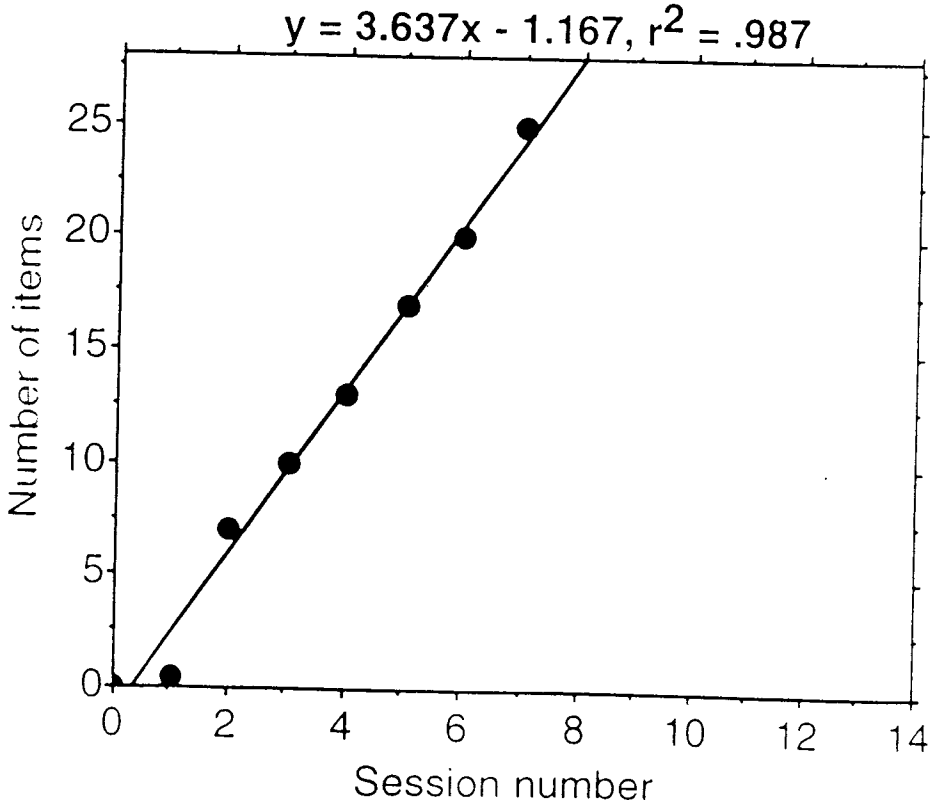
BD:	6/7/82
Date of initial stimulation	3/20/95
Category pre-training	4
Catedgory post-training	6
Cause of deafness	Meningitis
Age at onset	9 months

	Pre-test (2-10-95)	Post-test (4-21-95)
	B Aid	Spectra 22
Pattern Perception	100%	87%



BD:	6/7/82
Date of initial stimulation	3/20/95
Category pre-training	4
Catedgory post-training	6
Cause of deafness	Meningitis
Age at onset	9 months

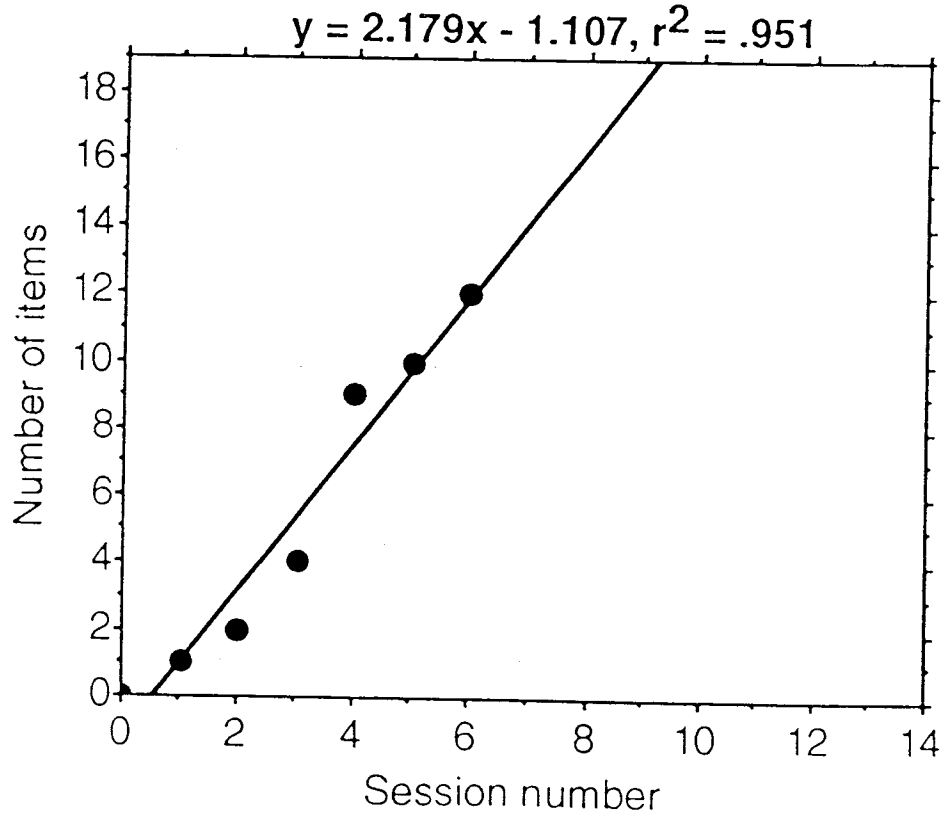
	Pre-test (2-10-95)	Post-test (4-21-95)
	B Aid	Spectra 22
Spondees	95%	100%
Monosyllables	50%	79%
WIPI	52%	72%
PBK	8%	28%



Child B Suprasegmentals

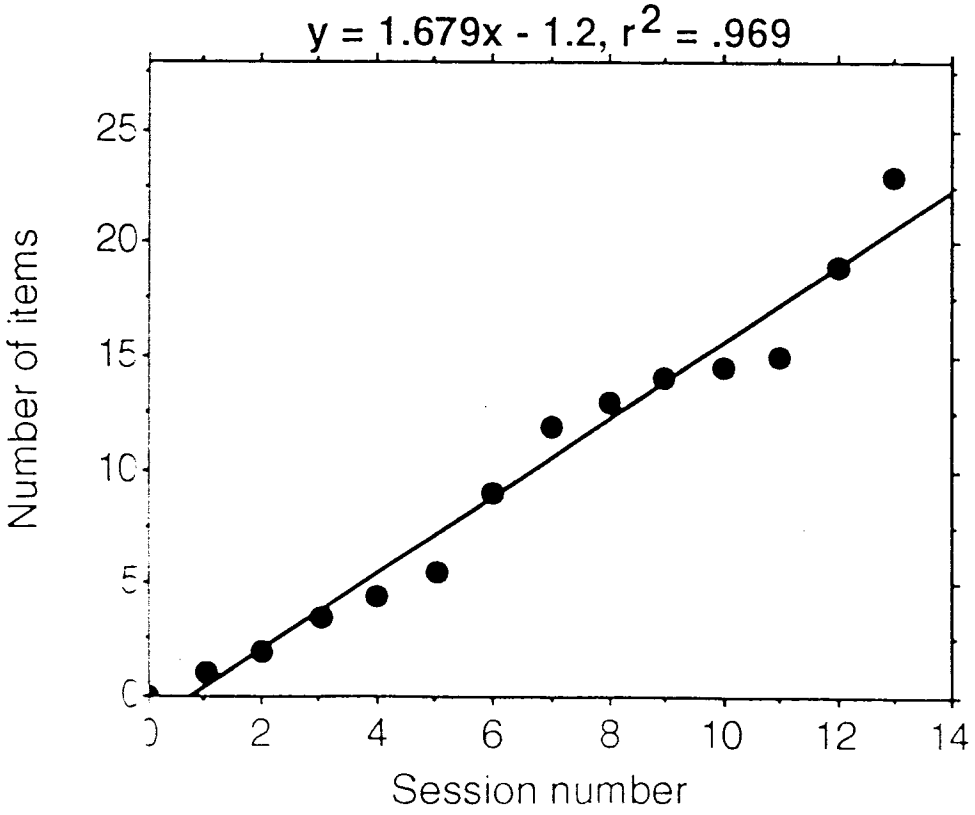
BD:	11/5/82
Date of initial stimulation	3/17/95
Category pre-training	3
Catedgory post-training	3
Cause of deafness	Unknown
Age at onset	Diagnosed 1yr. 11mos.

	Pre-test (8-22-95)	Post-test (5-2-95)
	B Aid	Spectra 22
Pattern Perception	83%	100%



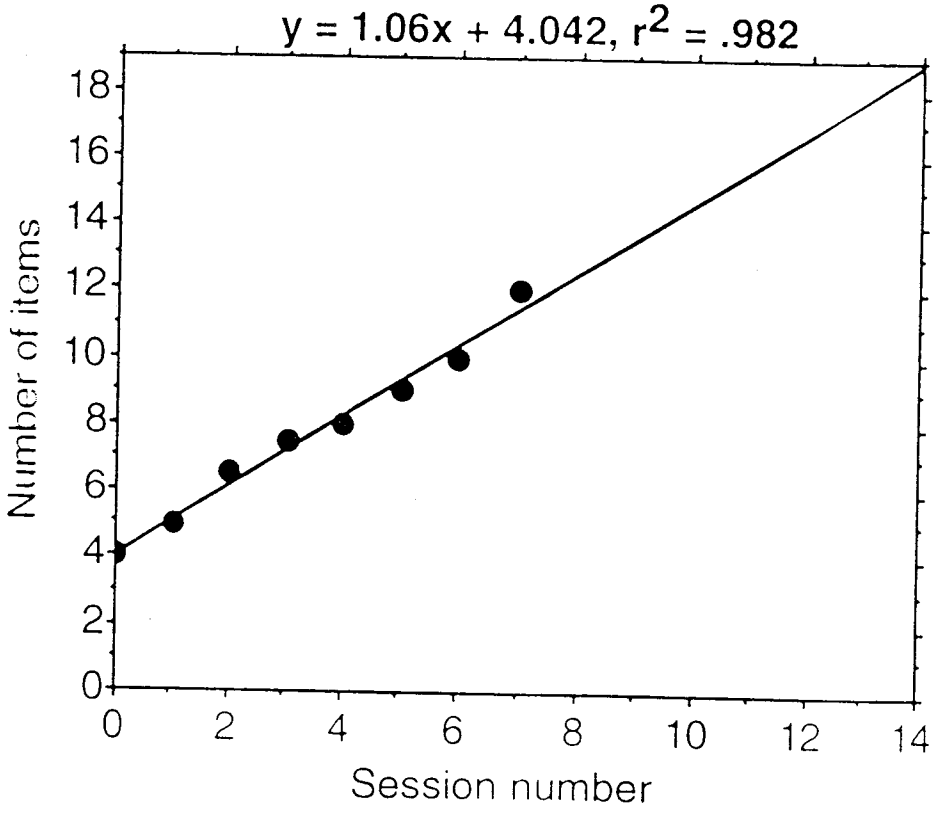
BD:	11/5/82
Date of initial stimulation	3/17/95
Category pre-training	3
Catedgory post-training	3
Cause of deafness	Unknown
Age at onset	Diagnosed 1yr. 11mos.

	Pre-test (8-22-95)	Post-test (5-2-95)
	B Aid	Spectra 22
Spondees	33%	71%
Monosyllables	50%	37%



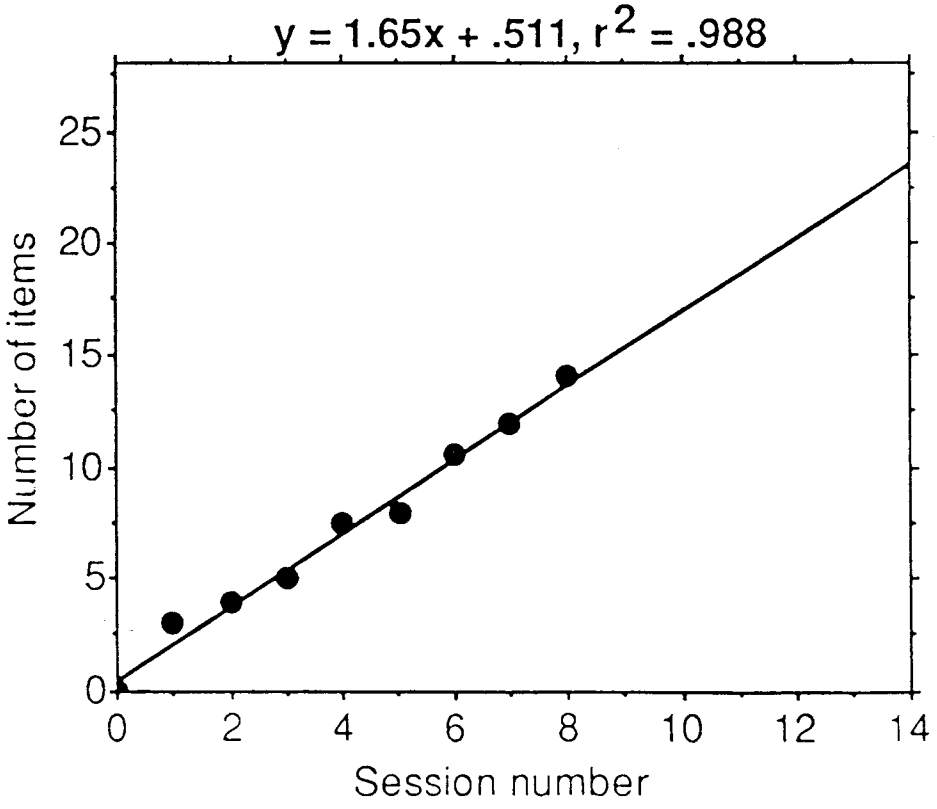
BD:	3/18/90
Date of initial stimulation	2/13/95
Category pre-training	2
Catedgory post-training	5
Cause of deafness	Meningitis
Age at onset	11 months

	Pre-test (9-19-94)	Post-test (4-20-95)
	Low-verbal Version, R Aid	Standard Version, Spectra 22
Pattern Perception	83%	100%



BD:	3/18/90
Date of initial stimulation	2/13/95
Category pre-training	2
Catedgory post-training	5
Cause of deafness	Meningitis
Age at onset	11 months

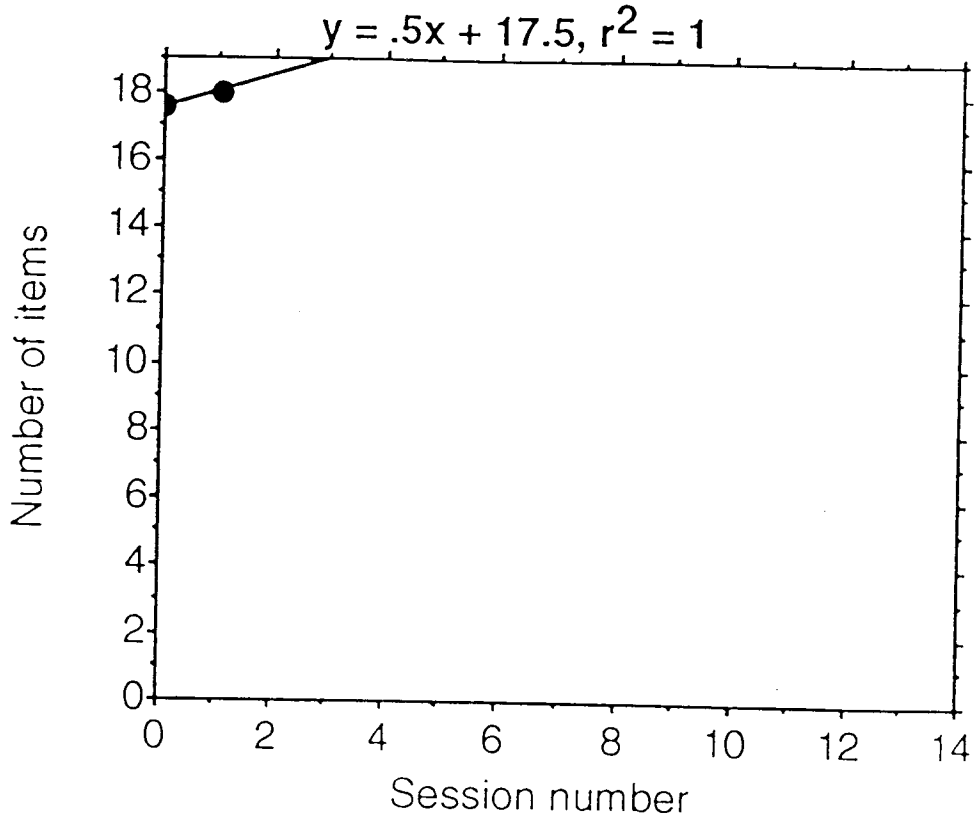
	Pre-test (9-19-94)	Post-test (4-20-95)
	Low-verbal Version, R Aid	Standard Version, Spectra 22
Spondees	33%	91%
Monosyllables	NT	58%
WIPI	NT	40%



Child D Suprasegmentals

BD:	7/3/83
Date of initial stimulation	10/3/94
Category pre-training	3
Catedgory post-training	3
Cause of deafness	Unknown
Age at onset	Diagnosed 9 months

	Pre-test (2-22-95)	During training (4-5-95)	Post-test (4-28-95)
	Spectra 22	Spectra 22	Spectra 22
Pattern Perception	83%	92%	NT



BD:	7/3/83
Date of initial stimulation	10/3/94
Category pre-training	3
Catedgory post-training	3
Cause of deafness	Unknown
Age at onset	Diagnosed 9 months

	Pre-test (2-22-95)	During training (4-5-95)	Post-test (4-28-95)
	Spectra 22	Spectra 22	Spectra 22
Spondees	54%	71%	66%
Monosyllables	NT	12%	41%